

(12) UK Patent Application (19) GB (11) 2 352 869 (13) A

(43) Date of A Publication 07.02.2001

(21) Application No 0013864.4

(22) Date of Filing 07.06.2000

(30) Priority Data

(31) 09333378

(32) 15.06.1999

(33) US

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(51) INT CL⁷

H01J 61/52 // G01J 3/10, H01J 61/04

(52) UK CL (Edition S)

H1D DBD3 DBT5 D11X D11Y D12B47Y D12B6 D35
D5C1 D5C2 D5C3 D5ZY

(56) Documents Cited

US 5633563 A US 5619101 A US 5552669 A
US 4366408 A

(58) Field of Search

UK CL (Edition R) H1D DBD3 DBT5
INT CL⁷ G01J 3/10, H01J 61/04 61/06 61/52
Online: WPI, EPODOC, JAPIO

(54) Abstract Title

Deuterium lamp with improved anode heat dissipation

(57) A lamp having a gas-filled envelope 21, cathode 22, anode 23, sealed electrical leads 24, window shielding electrode 25, cathode shielding electrode 26, focusing electrode 28 and ceramic support 29 where anode 23 is mounted on the rear of ceramic support 29 with no substantial obstruction to the rearward radiation of heat from the anode. The anode may have fins extending from it, a radiating surface with an undulating cross-section fixed to it or a baffle attached to it. The lamp may further comprise a shield extending from the rear surface of the support to surround the anode and prevent arcing between the anode and cathode. The gas may be deuterium and the envelope may be formed of UV-transmissive material.

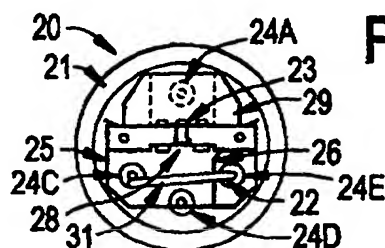


FIG. 3

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

FIG. 1

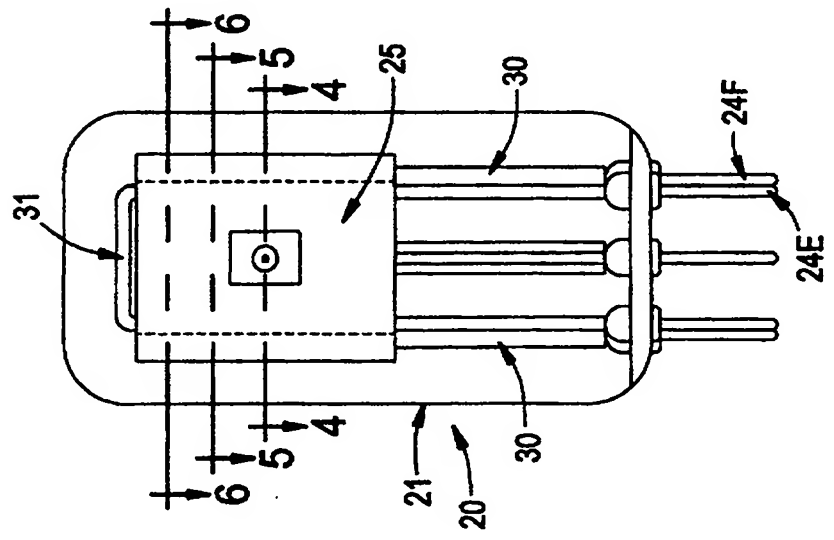


FIG. 2

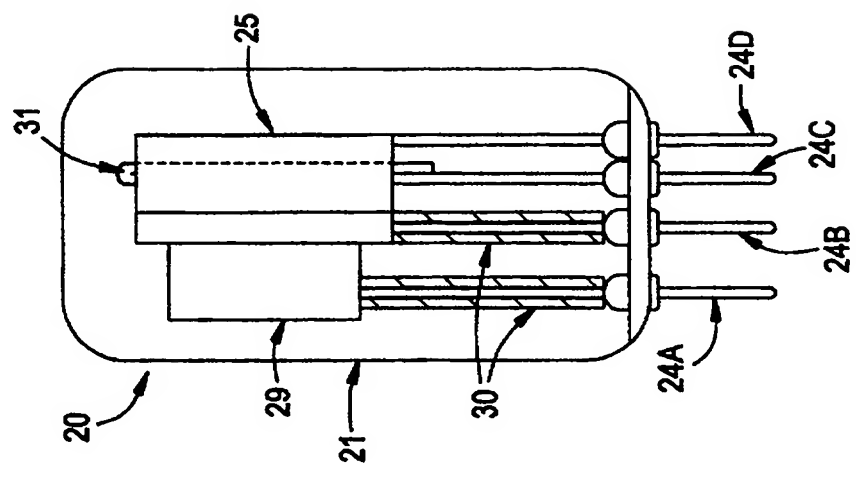


FIG. 3

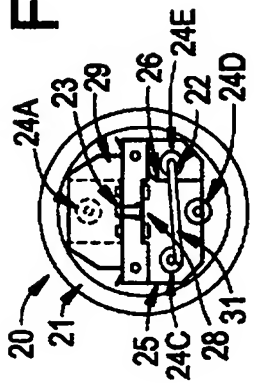


FIG. 4

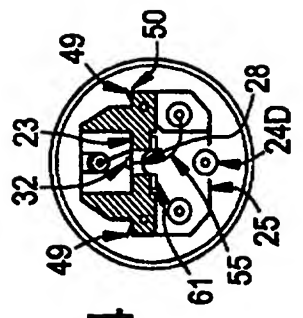


FIG. 5

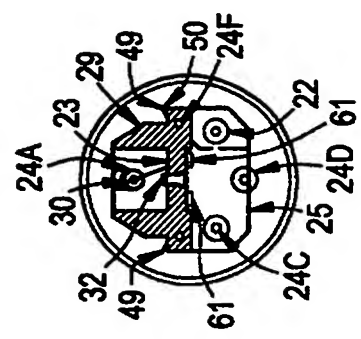


FIG. 6

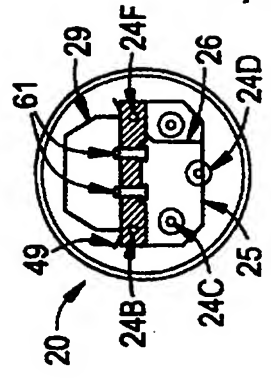


FIG. 10

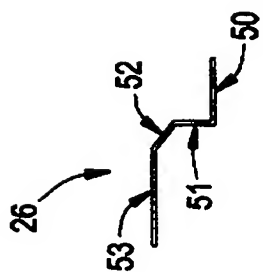


FIG. 8

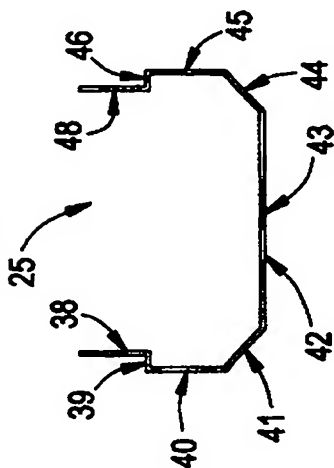


FIG. 11

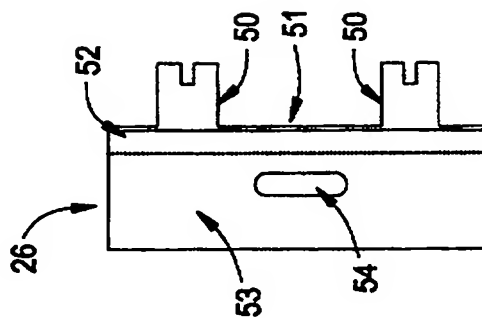


FIG. 7

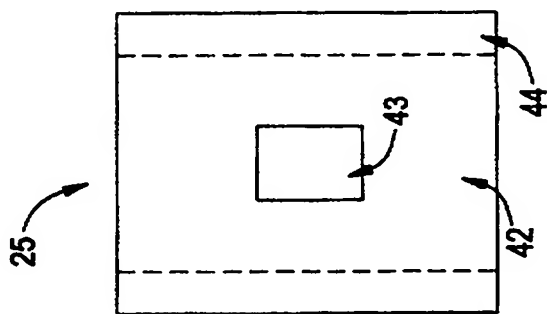


FIG. 9

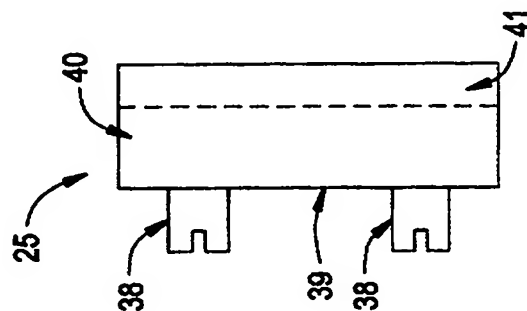


FIG. 13

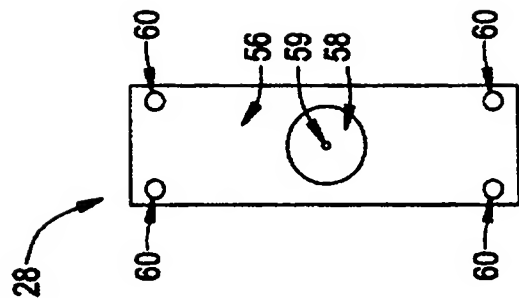
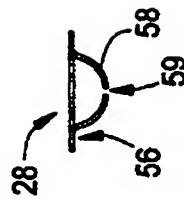


FIG. 12



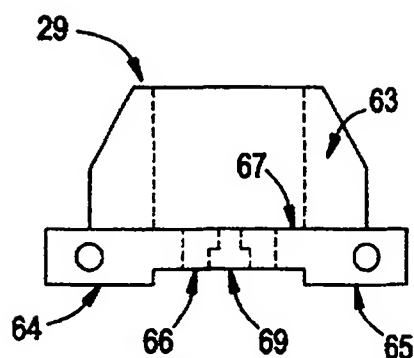


FIG. 14

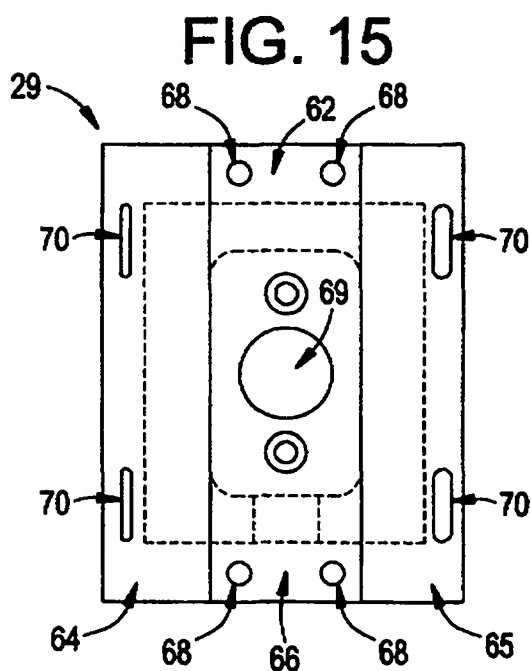


FIG. 15

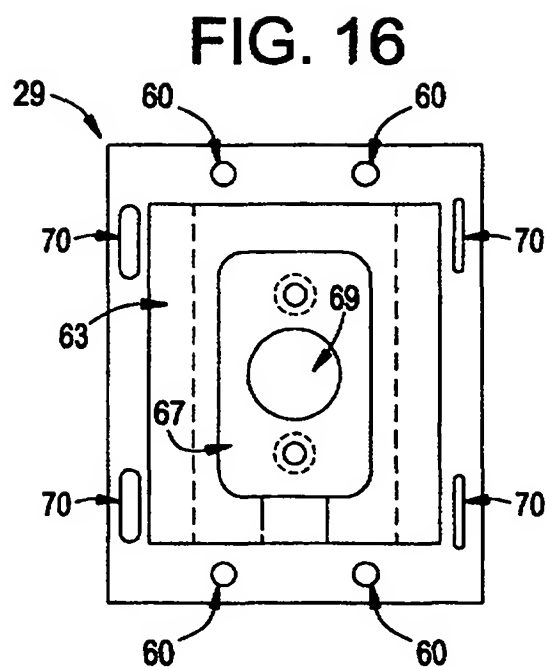
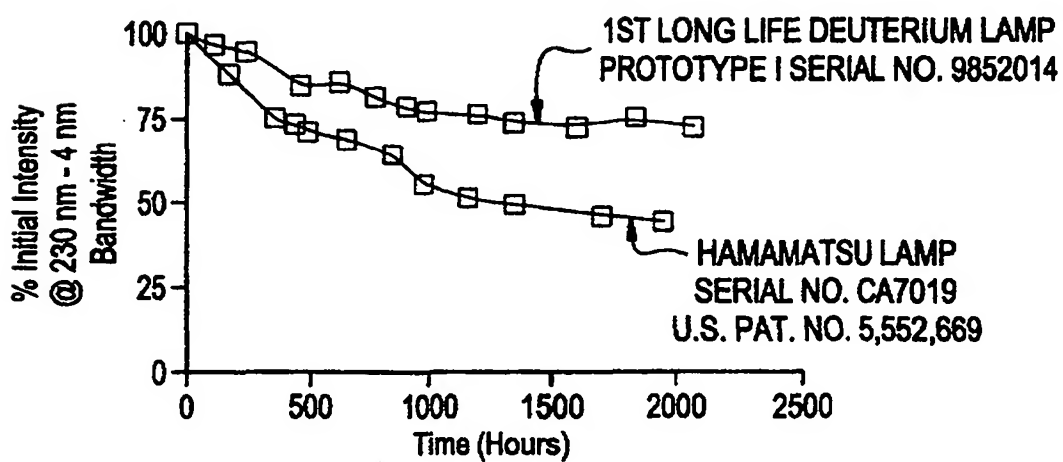


FIG. 16

FIG. 17



LONG-LIFE DEUTERIUM LAMP WITH IMPROVED HEAT DISSIPATION PROPERTIES

The present invention relates generally to the field of gas discharge
5 tubes, and, more particularly, to a long-life deuterium lamp having enhanced heat dissipation capabilities.

Deuterium is a hydrogen isotope of mass 2, and is commonly identified
by the symbol *D*. Deuterium occurs in nature as a diatomic molecule, and in com-
10 pounds.

Deuterium arc lamps are well-known sources of light in the range of
190-400 nanometers. They are commonly used in various spectral analyzers, such as
absorption detectors, spectral photometers, spectral scopes, and the like.

In general, deuterium lamps have an anode and a cathode arranged with-
15 in an elongated tubular envelope made of a UV-transmitting glass or quartz. A focus-
ing electrode is placed between the anode and the cathode. Deuterium gas is dosed
into the envelope at a pressure of a few torr. In many cases, mechanical structure
(*e.g.*, anode, focusing electrode, and the like) is supported within the glass envelope
on the distal ends(s) of one or more electrical conductors. Each conductor is generally
20 in the form of a rod-like member having a large length-to-diameter ratio, and normally
possesses sufficient strength to prevent or restrain axial movement of the mechanical
structure within the envelope.

When a sufficient voltage is applied to the electrodes, a stream of elec-
trons flow from the cathode to the anode. The electrons collide with the deuterium
25 gas molecules and excite them to higher energy levels. When the molecules return to
their ground state, energy is released in the form of photons in the UV range. The
focusing electrode serves to constrict and intensify the discharge of the lamp to a di-
ameter of one millimeter or smaller. The concentration of light by the focusing
electrode makes it useful in the application of absorption detectors and similar instru-
30 ments.

Details of prior art deuterium lamps are representatively shown in a catalog entitled "Deuterium Lamps and Power Supplies for UV Analytical instruments", Imaging and Sensing Technology Corporation, Horseheads, New York (undated), and in U.S. Patents No. 4,433,265, 4,910,431 and 5,117,150. These references all appear
5 to disclose different types of prior art deuterium lamps in which certain mechanical structure is cantilever-mounted on the distal end(s) of one or more electrical conductors. The aggregate disclosures of these various prior art references are hereby incorporated by reference.

Additional details of other known deuterium lamps are shown and described in U.S. Patents No. 5,552,669, 5,684,363, 5,619,101, 5,633,563 and
10 5,698,945. Each of these patents is facially assigned to Hamamatsu Photonics K.K. However, one problem attendant such prior art designs is believed to stem from the relatively short life of the lamp. This problem is believed to originate in the difficulty in dissipating heat from the anode. In this regard, the '669 patent appears to disclose
15 an anode sandwiched between a discharge shielding plate and a support plate. Hence, it appears that it is difficult for heat to dissipate from the anode. The '101 patent also shows the anode as being surrounded by an solid anode support member that tends to impede heat removal. The same is true of the '563 patent. The '363 patent appears to disclose an anode support plate to the rear of the anode. This anode support plate
20 would itself impede heat transfer from the anode. Here again, the aggregate disclosures of these patents are hereby incorporated by reference with respect to the structure and operation of such prior art deuterium lamps and various physical implementations of same.

Accordingly, it would be generally desirable to provide an improved
25 long-life deuterium lamp having enhanced heat transfer properties. It is thought that by facilitating the conveyance of heat away from the anode, the operational life of the lamp may be increased.

Generally, the life of a deuterium lamp is determined by its intensity. The lamp begins with an original intensity that degrades over time. When the
30 intensity falls below 50% of its initial value, it is said to have reached the end of its useful life. This is an industry standard that is recognized by most manufacturers of deuterium lamps, even though the lamp may technically still retain some utility after its intensity has fallen below 50% of its initial value.

According to the invention there is provided a lamp having a gas-filled glass envelope, a cathode, an anode, electrical leads sealingly penetrating the envelope and connected to the anode and cathode, respectively, a window-shielding electrode, a cathode-shielding electrode, a focusing electrode and a ceramic support, said ceramic support having a front surface facing toward said cathode, having a rear surface facing away from said cathode, and wherein said anode is held against said rear surface without substantially interfering with the radiation of said heat in a rearward direction from said anode.

The anode may be held against the support by at least one fastener, such as a rivet, a bolt, a screw, or the like. The ceramic support may possibly be provided with a tapped hole to receive the threaded marginal end portion of such fastener. A ceramic shield may extend rearwardly from the rear surface of the ceramic support so as to surround the anode and to prevent arcing from the anode to the cathode. The anode is recessed within this peripheral shield, but is exposed rearwardly. The envelope may be filled with deuterium gas. The envelope may be formed of a UV-transmissive material.

The improvement may further comprise means for increasing the surface area of the anode on the rear thereof, to enhance thermal radiation therefrom. These means may include, but are not limited to, a plurality of fins, a radiator surface having an undulating cross-section, and/or a baffle so as to shape and direct the flow of gas within the envelope.

A preferred embodiment of the invention will now be described, by way of example only, with reference to the accompanying drawings in-which:

Fig. 1 is a fragmentary front elevation of an improved deuterium lamp according to the present invention.

Fig. 2 is a left side elevation of the lamp shown in Fig. 1.

Fig. 3 is a top plan view of the improved lamp shown in Fig. 1.

Fig. 4 is an enlarged fragmentary horizontal sectional view thereof, taken generally on line 4-4 of Fig. 2, showing a portion of the mechanical structure supported on the uppermost distal ends of the leads, and showing the anode as being rearwardly

exposed but peripherally surrounded by a ceramic shield.

Fig. 5 is an enlarged fragmentary horizontal sectional view thereof, taken generally on line 5-5 of Fig. 1.

Fig. 6 is an enlarged fragmentary horizontal sectional view thereof, taken generally on line 6-6 of Fig. 1.

Fig. 7 is a front elevation of the window-shielding electrode.

Fig. 8 is a top plan view of the window-shielding electrode shown in Fig. 7.

Fig. 9 is a left side elevation of the window shielding electrode shown in Fig. 7.

Fig. 10 is a top plan view of the cathode-shielding electrode.

Fig 11 is a side elevation of the cathode-shielding electrode shown in Fig. 10.

Fig. 12 is a top plan view of the focusing electrode.

Fig. 13 is a front elevation of the focusing electrode shown in Fig. 12.

Fig. 14 is a top plan view of the ceramic support.

Fig. 15 is a front elevation of the ceramic support shown in Fig. 14.

Fig. 16 is a rear elevation of the ceramic support shown in Fig. 14.

Fig. 17 is a representative plot of percent of initial intensity (ordinate) vs. elapsed time (abscissa), showing a prototype of the improved lamp as having markedly improved life over a Hamamatsu lamp, Serial No. CA7019, that appears to be manufactured in accordance with the teaching of U.S. Patent No. 5,552,669.

At the outset, it should be clearly understood that like reference numerals are intended to identify the same structural elements, portions or surfaces, consistently throughout the several drawing figures, as such elements, portions or surfaces may be further described or explained by the entire written specification, of which this detailed description is an integral part. Unless otherwise indicated, the drawings are intended to be read (*e.g.*, cross-hatching, arrangement of parts, proportion, degree, etc.) together with the specification, and are to be considered a portion of the entire written description of this invention. As used in the following description, the terms "horizontal", "vertical", "left", "right", "up" and "down", as well as adjectival and adverbial derivatives thereof (*e.g.*, "horizontally", "rightwardly", "upwardly", etc.), simply refer to the orientation of the illustrated structure as the particular drawing figure faces the reader. Similarly, the terms "inwardly" and "outwardly" generally refer to the orientation of a surface relative to its axis of elongation, or axis of rotation, as appropriate.

Referring now to the drawings, and, more particularly to Figs. 1-4 thereof, the present invention broadly provides an improved deuterium lamp, of which a presently-preferred embodiment is generally indicated at 20. Lamp 20 is shown as broadly including a vertically-elongated gas-filled glass envelope 21; a cathode 22 (Fig. 3); an anode 23 (Fig. 3); a plurality of leads, severally indicated at 24 and individually identified by the suffix A, B, C, etc., sealingly penetrating the lowermost stem of envelope and connected to the anode and/or cathode, respectively (Figs. 1-2); a window-shielding electrode, generally indicated at 25; a cathode-shielding electrode 26; a focusing electrode 28; and a ceramic support 29. The improved lamp is filled with deuterium gas. A plurality of vertically-elongated tubular insulators, severally indicated at 30, surround the various leads and electrically insulate one from another, as well as provide a means for physically supporting the mechanical structure at the upper ends of such leads.

Cathode 22 includes a thermionic coil which is connected to one of pins 24. In Figs. 1-3, an overhead conductor 31 is shown as connecting cathode 22 with one of the other leads. This conductor does not appear in Figs. 4-16.

The anode 23 is shown as being a rectangular vertical plate-like member having a pair of vertically-spaced holes. As best shown in Fig. 5, these holes are

physically located above and below the central portion of the focusing electrode, and are designed to receive and accommodate passage of the shank portions of a pair of fasteners, one of which is indicated at 32. These fasteners may be rivets, bolts, or the like. Suffice it to say here that the shank portions of such fasteners pass through openings provided in ceramic mounting support 29, and through the anode holes. The distal ends of the fasteners are suitably turned or deformed so as to securely hold the anode to the rear surface of the ceramic mounting support. The anode has a rearwardly-facing planar vertical surface 33, and a forwardly-facing planar vertical surface 34 adapted to bear against the rearwardly-facing planar vertical surface 36 of the ceramic mounting support 29.

As best shown in Figs. 7-9, the window-shielding electrode 25 is depicted as being a vertically-elongated specially-configured articulated or bent plate-like member that sequentially includes leftward vertically-spaced rearwardly-extending tab portions 38, an leftwardly-extending lateral portion 39, a forwardly-extending portion 40, a forwardly- and rightwardly-inclined portion 41, a transversely-extending planar front portion 42 provided with a rectangular through-opening 43, a rightwardly- and rearwardly-extending inclined portion 44, a rearwardly-extending portion 45, a leftwardly-extending portion 46, and rightward rearwardly-extending vertically-spaced tab portions 48. Surfaces 48, 46, 45 and 44 are generally mirror images of surfaces 38, 39, 40 and 41, respectively. As best shown in Fig. 9, tab portions 38, 38 and 48, 48 extend rearwardly from surfaces 39, 46, respectively, and are designed and intended to be passed through cooperatively-configured slots, severally indicated at 70 (Figs. 15-16, provided in the ceramic support. Thereafter, the exposed distal ends of these tabs are adapted to be struck over or otherwise deformed, as severally indicated at 49 in Figs. 4-6, to securely hold the window-shielding electrode to the ceramic support.

Referring now to Figs. 4-6 and 10-11, the cathode-shielding electrode 26 is also shown as being a vertically-elongated specially-configured articulated or bent sheet-like member that sequentially includes rearwardmost vertically-spaced tab portions 50, 50, a transversely-extending portion 51, a leftwardly- and forwardly-extending planar portion 52, and a portion 53 continuing forwardly therefrom. Shield surface 53 is provided with a central slot-like opening 54 that is provided to accommodate passage of a stream of electrodes from the cathode to the anode along path 55

(Fig. 4). As best shown in Fig. 4, the forwardmost edge of cathode-shielding electrode portion 53 is positioned adjacent window-shielding electrode portion 42. The two rearwardly-extending tabs 50, 50 are passed through the slots 70 provided through the ceramic support, and are bent over or otherwise deformed (Figs. 4-6), to securely
5 lock and hold the shield 26 to the ceramic support.

As best shown in Figs. 12-13, the focusing electrode 28 is generally configured as a vertically-elongated plate-like member 56 and having a spherical dimple-shaped central portion 58 struck rearwardly therein. Thus, this dimple-shaped portion has a forwardly-facing spherical concave surface and a rearwardly-facing spherical
10 convex surface. The dimple-shaped portion is provided with a central horizontal through-hole 59 that is aligned with the anode. As best shown in Fig. 13, the plate-like portion is provided with four rectangularly-spaced mounting holes, severally indicated at 60, to receive and accommodate passage of a like number of fasteners, severally indicated at 61 in Fig. 6. These fasteners may be rivets, screws, or the like. Suf-
15 fice it to say here that fasteners 61 are used to securely hold the focusing electrode to the forward central surface of the ceramic support 29.

Referring now to Figs. 14-16, the ceramic support 29 is depicted as being a specially-configured integrally-formed dielectric member, which may be formed of alumina (Al_2O_3) or the like. The support is shown as having a forward plate-like portion 62, and a rearwardmost flange portion 63. The forward portion 62 is shown as
20 having forwardly-facing left and right planar vertical surfaces 64, 65, and a forwardly-facing central slightly-recessed surface 66. The forward portion has four holes, severally indicated at 68, that are adapted to be aligned with the four mounting holes 60 in the focusing electrode, and are further designed to accommodate passage of the shank portions of fasteners 61 (Fig. 6). The plate-like forward portion 62 is also depicted as
25 having a rearwardly-facing planar vertical surface 67 (Fig. 16).

The forwardly-facing surface of the anode is adapted to bear against ceramic support surface 67. In the preferred embodiment, the anode is held in this position by means of fasteners 32, 32 (Fig. 5). The ceramic flange portion 63 extends
30 rearwardly from plate-like forward portion 62, and peripherally surrounds the anode. In effect, the anode is recessed within the flange portion, but is exposed rearwardly to facilitate the radiation of heat therefrom. The principal purpose of flange portion 63 is to shield the anode from arcing about the front plate-like portion, and to assure that

the electrons flow in the direction of stream 55 (Fig. 4) from the cathode to the anode. The plate-like portion 62 is shown as having a through-hole 69 to receive and accommodate the spherical dimple in focusing electrode 28, and allow for passage of electrons from the cathode through the focusing electrode to the anode plate. As best
5 shown in Figs. 15 and 16, the ceramic support flange portion has four vertically-elongated slots, severally indicated at 70, to receive and accommodate passage of the rearwardly-extending tabs on the window-shielding and cathode-shielding electrodes.

The improved device is assembled as generally shown in Fig. 4. More particularly, the rearwardly-extending tabs on the cathode-shielding and window-
10 shielding electrodes are passed through support slots 70, and the distal ends thereof are bent over, as shown in Figs. 4-6, to securely hold them in this position. The anode plate is secured to the rear of the ceramic support, in the recess provided within flange portion 63, and is held in this position by means of vertically-spaced fasteners 32, 32. The focusing electrode is operatively mounted on the central recessed surface 66 of
15 the ceramic shield, and may be held in this position by means of the four fasteners indicated at 61. The structure is placed within a tube, and is substantially filled only with deuterium gas. When the lamp is energized, electrons issue from the cathode 22 and travel along path 55 (Fig. 4) through focusing electrode hole 59 to the anode. It should be noted in the arrangement shown in Fig. 4, that the anode is rearwardly ex-
20 posed in that there is substantially no heat transfer-impeding material to the rear of it. Hence, in operation, heat from the anode may radiate rearwardly and be discharged from the lamp.

If desired, a fin assembly or another surface area-increasing undulating member may be operatively secured to the rear of the anode to increase the thermal
25 radiation surface.

Thus, the improved lamp is particularly designed and configured so as to facilitate thermal radiation rearwardly from the anode. This feature immediately distinguishes the improved lamp from prior art lamps, which provide a radiation-impeding mass to the immediate rear of the anode. Indeed, some prior art devices sandwich
30 the anode between other supports. Hence, heat from the anode must travel first by conduction through the radiation-impeding mass, before it can be dissipated.

The improved lamp has been found to offer increased life over those afforded by prior art lamps, such as those designed in accordance with the teachings of

U.S. Patent No. 5,552,669. Fig. 17 is a representative plot of percent initial intensity (ordinate) at 230 nanometers (4 nanometer bandwidth) vs. time (abscissa) expressed in hours. In this regard, the ordinate expresses the percentage diminution in the initial intensity. Otherwise stated, when the lamp is initially put into service at $t = 0$ hours, the lamp will have an initial intensity. Thereafter, the intensity of the lamp is expressed as a percentage of its initial intensity. The data plotted in Fig. 17 illustrates the life of the improved lamp versus the life of a prior art lamp that appears to have been manufactured in accordance with the teachings of U.S. Patent No. 5,552,669. It should be noted that the intensity of the improved lamp herein is consistently higher than the intensity of the prior art lamp, and that the disparity therebetween appears to generally increase with passage of time. Thus, at $t = 500$ hours, the improved lamp has the intensity of approximately 80-85% of its original intensity, whereas the prior art lamp is about 70% of its original intensity. At $t = 1,000$ hours, the improved lamp has an intensity of about 80% of its original value, whereas the intensity of the prior art lamp as been reduced to about 55% of its original value. At $t = 1,500$ hours, the intensity of the improved lamp is about 70% of its original value, whereas the intensity of the prior art lamp has been reduced to about 50% of its original value. At $t = 2,000$ hours, the intensity of the improved lamp is still about 70-75% of its original intensity, whereas the prior art lamp actually failed at about $t = 1,800$ hours.

The above-described data is generally the output of a product life test. In this case, both the prior art lamp and the improved lamp were tested in separate instruments operated under identical conditions. The instruments used for this test were Waters 2487 UV Absorbance Detectors, used in the field of liquid chromatography. Although lamps were operated in two separate instruments, the intensity measurements were obtained by a separate third instrument, ensuring that the data was not influenced by and differences between the instruments, and to eliminate, as much as possible, instrument degradation that may occur over time. This is a common method of testing the life of deuterium lamps.

Therefore, the improved lamp offers the principal advantage of longer life than prior art lamps. It is believed that the longer life of the improved lamp is attributable to its improved heat dissipation characteristics, as compared with those of the prior art lamps.

Modifications

Of course, the present invention contemplates that many changes and modifications may be made. For example, the shape and structure of the window-shielding and cathode-shielding electrodes may be readily changed or modified. The ceramic support may be formed of alumina or some other dielectric material. The flange and plate portions thereof may be formed separately or integrally. The various electrodes may be formed of nickel or the like. The anode may be attached differently to the rear of the ceramic support, as may be the focusing electrode. If desired, other devices may be mounted on the rear of the mechanism to improve the heat radiation properties thereof.

Therefore, while a preferred embodiment of the improved lamp has been shown and described, and several modifications thereof discussed, persons skilled in this art will readily appreciate that various additional changes and modifications may be made without departing from the scope of the invention, as defined by the following claims.

Claims

1. A lamp having a gas-filled glass envelope, a cathode, an anode, electrical leads sealingly penetrating the envelope and connected to the anode and cathode, respectively, a window-shielding electrode, a cathode-shielding electrode, a focusing electrode and a ceramic support, said ceramic support having a front surface facing toward said cathode, having a rear surface facing away from said cathode, and wherein said anode is held against said rear surface without substantially interfering with the radiation of said heat in a rearward direction from said anode.
2. A lamp according to claim 1, wherein said anode is held against said support rear surface by a rivet.
3. A lamp according to claim 1, wherein said anode is held against said support rear surface by a bolt.
4. A lamp according to claim 3, wherein said ceramic support is provided with a tapped blind hole to receive the threaded marginal end portion of said bolt.
5. A lamp according to claim 1, and further comprising a shield extending rearwardly from the rear surface of said ceramic support and surrounding said anode to prevent arcing from said anode to said cathode.

6. A lamp according to claim 1, wherein said envelope is filled with deuterium gas.
7. A lamp according to claim 1, wherein said envelope is formed of a UV-transmissive material.
8. A lamp according to claim 1, and further comprising means for increasing the surface area of said anode to enhance heat radiation therefrom.
9. A lamp according to claim 8, wherein said means comprises a plurality of fins extending away from said anode.
10. A lamp according to claim 8, and further comprising a radiator surface having an undulating cross-section fixed to said anode.
11. A lamp according to claim 8, and further comprising a baffle fixed to said anode.
12. A lamp substantially as described with reference to the accompanying drawings.



Application No: GB 0013864.4
Claims searched: 1-8

Examiner: Rachel Foxon
Date of search: 23 November 2000

Patents Act 1977 Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.R): H1D (DBD3) (DBT5)

Int Cl (Ed.7): H01J 61/04, 61/06, 61/52 G01J 3/10

Other: Online: WPI, EPODOC, JAPIO

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
A	US 5633563	Hamamatsu Protonics K.K. (See esp col 2 lines 7-14)	-
X	US 5619101	Hamamatsu Protonics K.K. (See esp col 6 lines 1-8)	1,6,7
A	US 5552669	Hamamatsu Protonics K.K. (See 24,21,25,26,23 in figs)	-
A	US 4366408	Pye (Electronic Products) Ltd.	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.